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Evaluating the Effectiveness of Space Allocation in Controlling Traffic and Circulation in Shopping Mall Designs

[1]Akeredolu Prince, [2]Dr. Steve Jayeoba & [3]Lawal S. Badedale

Caleb University, Department of Architecture, Imota, Lagos.
Corresponding email: akeredoluprince55@gmail.com
Telephone: +234 811 927 6528

ABSTRACT

Efficient pedestrian circulation is crucial for enhancing user experience and managing congestion in shopping malls. This study examines the influence of spatial configuration, store placement, and vertical circulation elements on pedestrian flow and movement efficiency. Using a mixed-methods approach, data were collected through direct observations, passenger flow analysis, and structured questionnaires from 196 respondents. Findings reveal that poorly distributed anchor stores create congestion hotspots, while escalators remain the most preferred vertical circulation method, despite bottlenecks at landing points. Additionally, inadequate wayfinding systems and inefficiently placed public seating areas contribute to navigation challenges. Technological interventions such as smart wayfinding and occupancy monitoring improve traffic distribution, though a significant number of visitors still rely on traditional navigation methods. The study recommends optimized spatial planning, better wayfinding systems, and an integrated approach to digital and physical navigation tools to enhance circulation efficiency in shopping malls.

Keywords: Pedestrian flow, shopping malls, spatial configuration, vertical circulation, wayfinding systems, congestion management, technological interventions.

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1.0 Introduction

1.1 Background of the Study

Shopping malls serve as commercial and social hubs that influence urban economies, consumer behavior, and spatial organization. Effective space allocation significantly impacts pedestrian movement, traffic control, and overall user experience (Berezko, 2021). Proper spatial configuration ensures seamless circulation, prevents congestion, and enhances both commercial efficiency and shopper satisfaction (Fezzai et al., 2020). However, beyond optimizing circulation, other critical factors—such as economic viability, environmental sustainability, regulatory frameworks, and accessibility—must be integrated into shopping mall design to create a more efficient and inclusive environment. From an economic standpoint, poor space allocation negatively affects retail performance and mall profitability. Congested areas near anchor stores, combined with underutilized retail spaces, disrupt customer flow and reduce the visibility of smaller tenants, leading to uneven foot traffic distribution (Babaee et al., 2022). Additionally, inefficient circulation patterns increase operational costs, as high-traffic zones require more frequent maintenance, while isolated sections struggle with low commercial activity (Flamand, Ghoniem, & Maddah, 2023). Malls that integrate well-structured layouts and strategic store placement experience higher sales, better customer retention, and overall economic sustainability (Pathirana et al., 2023). Environmental considerations also play a crucial role in mall design. Poorly planned spaces can lead to increased energy consumption, particularly in ventilation and lighting systems (Yin et al., 2020). Inefficient air circulation caused by congestion and poorly placed entrances or atriums can raise cooling costs and decrease indoor air quality. Sustainable design strategies, such as incorporating green spaces, optimizing airflow, and using energy-efficient lighting, can reduce environmental impact while enhancing the shopping experience (Riaz et al., 2024).

Despite the importance of well-planned circulation, **policy and regulatory frameworks** guiding space allocation in shopping malls are often inadequate. Weak zoning laws and outdated building codes fail to enforce optimal circulation designs, leading to overcrowded pathways and ineffective wayfinding systems (Zhou & Liu, 2021). The absence of clear regulations on pedestrian movement planning, emergency exits, and accessibility standards further exacerbates circulation challenges. Strengthening policies to align with modern urban planning standards will improve shopping mall efficiency and safety (Zhang & Park, 2021). Another critical yet underdeveloped aspect in mall design is accessibility for people with disabilities. Many shopping malls fail to accommodate individuals with mobility impairments, relying on outdated infrastructure that lacks wheelchair-friendly walkways, well-positioned elevators, and adequate signage for visually impaired shoppers (Hosseini, Yeganeh, & Jalali, 2024). Poorly placed escalators and staircases also hinder smooth navigation, making it difficult for people with disabilities to move freely (Şahin & Çevik, 2024). Implementing universal design principles—such as wider corridors, clear signage, automated doors, and digital wayfinding solutions—will create a more inclusive and user-friendly environment.

1.2 Aim

To evaluate the effectiveness of space allocation in controlling traffic and circulation in shopping mall designs, with a focus on optimizing spatial organization to enhance user experience, reduce congestion, and improve overall functionality.

1.3 Objectives

1. To analyze how spatial configuration and store placement influence pedestrian flow and circulation efficiency in shopping malls.

2. To assess the impact of vertical circulation elements, such as escalators, elevators, and staircases, on visitor movement and traffic distribution.
3. To investigate the role of public spaces, rest areas, and wayfinding systems in managing crowd density and improving navigation within shopping malls.
4. To explore the influence of technological interventions, such as occupancy monitoring and smart wayfinding systems, on optimizing space allocation for better traffic control.

2.0 Literature Review

2.1 Spatial Configuration and Circulation Efficiency

Spatial coordination and circulation efficiency are fundamental to shopping mall functionality. Studies have shown that well-structured layouts significantly improve pedestrian and vehicular traffic flow, ensuring a seamless shopping experience. Effective space allocation plays a crucial role in balancing high-traffic zones and minimizing congestion, particularly near entrances, food courts, and vertical circulation points (Andi, Abednego, & Gultom, 2021). The use of space syntax analysis has proven effective in optimizing mall layouts by identifying key circulation routes and improving spatial accessibility (Fezzai et al., 2020). One critical aspect of space allocation involves the strategic placement of retail categories. Poorly distributed anchor stores create congestion hotspots, reducing circulation efficiency and affecting retail performance. Studies suggest that a balanced distribution of high-traffic stores helps to evenly disperse customer flow, preventing bottlenecks and ensuring equal accessibility to all sections of a shopping mall (Babaee et al., 2022). Furthermore, store-wide shelf placement also influences circulation patterns, as strategic product positioning can guide shopper movement and enhance retail engagement (Flamand, Ghoniem, & Maddah, 2023).

2.2 Economic and Environmental Factors in Shopping Mall Design

Beyond spatial planning, economic and environmental factors influence shopping mall design and efficiency. Poor circulation patterns not only increase congestion but also impact long-term operational costs due to excessive wear in high-footfall areas. Malls with optimized layouts experience better retail performance, higher customer retention, and reduced maintenance costs (Pathirana et al., 2023). Additionally, poor ventilation and lighting strategies contribute to increased energy consumption, negatively affecting sustainability. Research highlights the importance of integrating energy-efficient solutions, such as optimized air circulation systems and natural lighting, to reduce environmental impact while enhancing the overall shopping experience (Yin et al., 2020). Shopping malls designed with green spaces and sustainable materials also attract environmentally conscious consumers and contribute to urban sustainability goals (Riaz et al., 2024).

2.3 Policy and Regulatory Considerations

The effectiveness of wayfinding systems is another major factor in circulation planning. Studies highlight that inadequate signage and complex layouts often result in navigation challenges, leading to congestion in certain areas (Zhang & Park, 2021). The integration of smart wayfinding systems, such as digital maps and occupancy monitoring, has proven effective in improving shopper navigation while reducing unnecessary crowding in high-traffic sections of malls (Pathirana et al., 2023). However, regulatory frameworks guiding space allocation remain underdeveloped. Weak zoning laws and outdated building codes

often fail to enforce optimal circulation layouts, creating inefficiencies that impact both pedestrian movement and overall mall functionality (Zhou & Liu, 2021). Stricter policies that mandate improved circulation strategies, proper emergency exits, and universal wayfinding tools could significantly enhance mall accessibility and safety.

2.4 Accessibility for People with Disabilities

Accessibility for people with disabilities is another area that requires more consideration in shopping mall design. Many malls lack sufficient provisions for wheelchair users, poorly positioned elevators, and inadequate signage for visually impaired visitors, making navigation difficult (Hosseini, Yeganeh, & Jalali, 2024). The absence of accessible rest areas and seating zones also creates challenges for individuals with mobility impairments. Research suggests that incorporating wider pathways, clearly marked accessible routes, and digital wayfinding solutions can improve accessibility and enhance user experience (Şahin & Çevik, 2024). Additionally, malls that implement interactive signage with audio and tactile guidance for visually impaired shoppers create more inclusive environments, ensuring that all visitors can navigate the space comfortably.

2.5 Case Studies

2.5.1 Festival Mall

Festival Mall in Festac is a relatively new addition to the commercial landscape of Lagos. Its design integrates retail, entertainment, and leisure facilities, making it a multi-use space that attracts diverse visitors. A key aspect of its spatial organization is its wide corridors and strategic placement of anchor stores, which encourage a smooth flow of foot traffic (Babaee et al., 2022). By adopting a layout that allows for seamless movement between stores, the mall minimizes bottlenecks that typically occur in high-footfall areas. Additionally, the open atrium design enhances visual connectivity, enabling shoppers to orient themselves easily, thus reducing unnecessary congestion (Hosseini, Yeganeh, & Jalali, 2024). However, despite these design advantages, peak hours see increased congestion at the food court and cinema entrances due to limited queuing spaces, which could be improved through better spatial demarcation.

2.5.2 Ikeja City Mall

Ikeja City Mall, one of the busiest retail hubs in Lagos, demonstrates how strategic space allocation influences circulation efficiency. Unlike Festival Mall, Ikeja City Mall features a more linear layout, with stores arranged along a central corridor. This design effectively distributes foot traffic and reduces congestion at key access points (Andi, Abednego, & Gultom, 2021). The presence of multiple entry and exit points further aids circulation, as shoppers can navigate the space without excessive clustering in one location. Furthermore, the zoning of food courts, entertainment zones, and retail sections ensures that traffic is evenly dispersed, preventing localized congestion (Çavka, 2023). The incorporation of wide walkways and strategically placed seating areas encourages rest stops, reducing the likelihood of pedestrian traffic jams (Park & Zhang, 2019). Despite these strengths, Ikeja City Mall experiences circulation challenges, particularly during special sales events and holidays. During these periods, overcrowding is noticeable at checkout counters and popular retail stores, as the current aisle widths do not adequately accommodate peak-hour traffic (Deb & Mitra, 2020). This issue is compounded by the lack of adequate wayfinding signage, which

can cause directional confusion, particularly for first-time visitors (Zhang & Park, 2021). To address these challenges, implementing dynamic digital wayfinding systems and reorganizing high-traffic zones could significantly enhance circulation efficiency.

2.6Public Open Spaces and Their Influence on Pedestrian Circulation

One of the key determinants of effective circulation in both malls is the role of parking lot design. Research suggests that poorly planned parking layouts can significantly disrupt interior traffic flow (Elistratov, 2019). Festival Mall incorporates a relatively compact parking arrangement, which sometimes leads to congestion at entry points during busy hours. In contrast, Ikeja City Mall benefits from a larger parking space with multiple access routes, which reduces vehicular congestion. However, both malls could benefit from integrating real-time parking availability systems to streamline entry and exit processes (Wang et al., 2020). Another factor influencing spatial efficiency is the arrangement of commercial units in relation to anchor tenants. In both malls, anchor stores such as supermarkets and major retail brands are positioned strategically to attract customers into deeper sections of the shopping center (Babaee et al., 2022). This arrangement helps distribute traffic more evenly, ensuring that smaller retail outlets also receive foot traffic rather than remaining isolated. However, the effectiveness of this strategy is sometimes undermined by the clustering of high-demand stores in a single zone, leading to periodic congestion (Oktaviana & Anggraeni, 2022). A more dispersed distribution of anchor stores, combined with multiple attraction points, could mitigate these issues. The role of vertical circulation elements such as escalators, elevators, and staircases cannot be overlooked in evaluating space allocation (Hosseini, Yeganeh, & Jalali, 2024). In both malls, escalators are strategically placed near anchor stores to encourage movement between floors. However, Festival Mall's escalator positioning occasionally results in bottlenecks due to inadequate landing space. Ikeja City Mall, on the other hand, benefits from a more balanced distribution of vertical access points, which enhances movement efficiency. Research indicates that increasing the number of vertical access points and optimizing their placement can significantly improve circulation (Şahin & Çevik, 2024).

Public open spaces and social interaction zones also contribute to effective circulation. Berezko (2021) highlights the importance of integrating communal areas within shopping malls to reduce traffic congestion and improve user experience. Festival Mall's open central atrium serves this purpose well, allowing visitors to gather without obstructing pathways. Ikeja City Mall, while featuring several seating areas, could benefit from more expansive communal zones to alleviate pedestrian congestion during peak hours (Sasmita, Soemardiono, & Noerwasito, 2020). Additionally, the introduction of digital occupancy monitoring systems could help regulate the distribution of shoppers, ensuring a more balanced circulation pattern (Pathirana et al., 2023). Despite the role of spatial planning in circulation efficiency, accessibility for people with disabilities remains an underdeveloped aspect in shopping mall designs. Many malls fail to provide adequate provisions such as wheelchair-friendly pathways, accessible rest areas, and well-positioned elevators, making navigation difficult for individuals with mobility impairments (Hosseini, Yeganeh, & Jalali, 2024). Inadequate tactile signage and poor wayfinding systems also create challenges for visually impaired visitors, further limiting accessibility (Şahin & Çevik, 2024). Ensuring that public open spaces incorporate inclusive design elements—such as wider corridors, strategically placed ramps, and interactive wayfinding tools—will enhance accessibility and create a more inclusive shopping environment. Overall, the effectiveness of space allocation in controlling traffic and circulation within Festival Mall and Ikeja City Mall is evident in their strategic layout designs. While both malls exhibit well-planned circulation strategies,

certain areas require optimization to further enhance user experience. The incorporation of adaptive spatial solutions, such as dynamic wayfinding systems, optimized vertical circulation elements, and improved parking management, would significantly enhance the functionality of these shopping environments. Future research should explore the impact of emerging technologies, such as AI-driven space management systems, in further refining circulation efficiency and ensuring accessibility in shopping mall designs.

2.7 Study Area

This study examines how space allocation influences traffic control and circulation efficiency in shopping malls, using Festival Mall (Festac) and Ikeja City Mall (Ikeja) as case studies. Lagos, a commercial hub, faces significant crowding in retail spaces, making these malls ideal for analysis.Festival Mall, integrated into a residential area, features designated retail and entertainment zones but experiences congestion at entrances and food courts. Ikeja City Mall, a high-traffic commercial hub, utilizes multiple access points and anchor tenants to guide movement but faces crowding near escalators and major stores.By analyzing their spatial strategies, this study evaluates how effective design can enhance circulation and reduce congestion in urban malls.\

2.8 Study Population and Size

The study population includes mall visitors, retail store owners, and facility managers at Festival Mall and Ikeja City Mall. Visitors' movement patterns reveal circulation efficiency, while store owners provide insights on foot traffic impact. Facility managers contribute knowledge on space management and crowd control. Together, these groups offer a comprehensive view of how space allocation affects traffic flow in shopping malls.To determine an appropriate sample size, Cochran's formula was applied, considering a 95% confidence level, an estimated population proportion of 50%, and a 7% margin of error. This calculation resulted in a required sample size of 196 respondents, ensuring statistical reliability. The chosen sample size is sufficient for drawing meaningful conclusions while remaining practical in terms of data collection. It aligns with existing studies on shopping mall circulation, where sample sizes typically range between 150–250 respondents for robust analysis (Zhang & Park, 2021).

2.9 Data Collection Method

This study employs a mixed-methods approach to data collection, combining direct observation, spatial analysis, and user feedback. Field observations will document visitor movement patterns, congestion points, and peak-hour circulation challenges within Festival Mall and Ikeja City Mall. Space syntax analysis will assess the effectiveness of spatial organization in guiding foot traffic. Additionally, structured surveys and brief interviews with shoppers and mall staff will provide insights into perceived ease of navigation, crowding issues, and user experience. Secondary data from existing research and architectural plans will supplement findings, ensuring a comprehensive evaluation of how space allocation impacts circulation efficiency.

2.10 Data Analysis

The data analysis integrates qualitative and quantitative methods. Observational data will identify congestion patterns and queuing times, while passenger flow analysis tracks

movement trends. Questionnaire responses from passengers and staff will be analyzed statistically to assess travel experiences and congestion issues. Secondary data from ferry operators will be examined for traffic volumes and scheduling inefficiencies, ensuring a comprehensive understanding of terminal operations.

3.0 Results and Discussion

3.1 Demographic Information

1. Age Distribution Analysis: The bar chart shows that 45% of respondents fall within the 26-40 years' age group, making them the dominant shoppers who are most affected by mall congestion. The 18-25 years' group (30%) consists of younger visitors who frequently visit malls and are highly adaptable to technology. The 41-60 years' group (20%) is less frequent but values convenience and accessibility. The 60+ years category (5%) represents elderly visitors who rely more on seating areas and elevators.

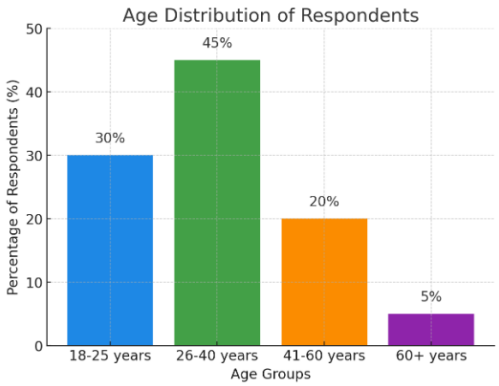


Figure 1: bar chart showing age distribution

2. Gender Distribution Analysis: The pie chart shows that the respondents were fairly balanced in gender, with 52% female and 48% male. Males prioritized efficiency and preferred escalators over elevators, while females were more likely to use public seating areas and reported greater difficulty with navigation due to unclear wayfinding systems.

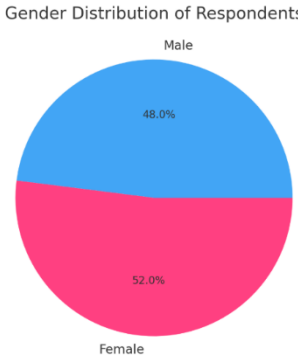


Figure 2: pie chart showing gender distribution

3. Shopping Frequency Analysis: The bar chart indicates that 40% of respondents visit shopping malls weekly, making them highly aware of congestion and circulation inefficiencies. 35% are occasional (monthly) visitors, who experience but may not be

significantly affected by crowding. 25% visit rarely (a few times a year), meaning their concerns about layout and congestion are less pronounced compared to frequent shoppers.

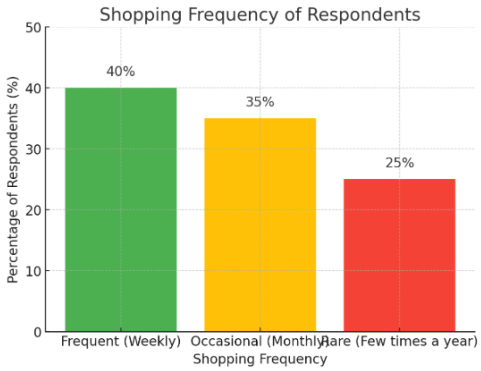


Figure 3: bar chart showing shopping frequency

3.2 Analysis Based On Objectives

3.2.1 Impact of Store Placement on Pedestrian Flow: The pie chart illustrates how respondents perceive the influence of store placement on their movement within shopping malls. A majority of the respondents (68%) believe that store arrangement significantly affects pedestrian flow, with 35% strongly agreeing and 33% agreeing. Meanwhile, 12% remain neutral on the matter. On the other hand, 20% of respondents do not find store placement influential, as 10% disagree and another 10% strongly disagree.

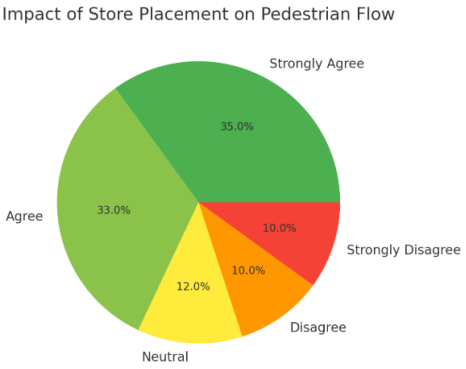


Figure 4: pie chart showing the impact of store placement on pedestrian flow

3.2.2 Preferred Vertical Circulation Methods: The bar chart highlights visitor preferences for vertical movement in shopping malls. A significant 75% of respondents prefer escalators, indicating their efficiency and ease of use. Elevators are used by 56% of visitors, primarily among the elderly and families, though delays were a common concern. In contrast, only 30% of visitors use staircases, suggesting they are underutilized, possibly due to accessibility challenges or a lack of motivation to use them.

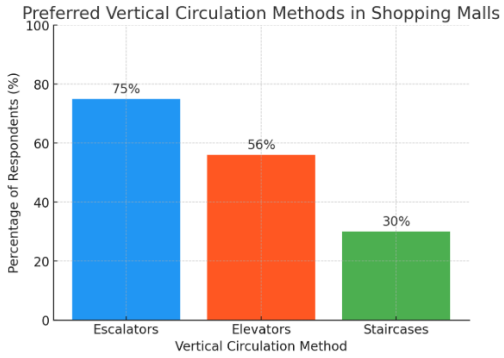


Figure 5: bar chart showing preferred vertical circulation methods in shopping malls

3.2.3 The role of public spaces and wayfinding

Factor	Positive Feedback (%)	Negative Feedback (%)
Public seating availability	81	19
Wayfinding clarity	40	60
Rest area placement	45	55

Table 1: the role of public spaces and wayfinding

Findings: The table presents insights into public seating, wayfinding clarity, and rest area placement. A significant 81% of respondents found public seating essential, indicating a strong demand for more rest zones. Additionally, 60% reported difficulty with wayfinding, suggesting that signage and navigation tools need improvement. Furthermore, 55% were dissatisfied with the placement of rest areas, highlighting the need for strategic positioning to prevent congestion and enhance user experience.

3.2.4 Effectiveness of Technological Interventions

The graph represents respondents' feedback on the impact of different technological interventions in managing mall traffic. A majority of 72% found smart wayfinding helpful, as it improved navigation within the mall. Additionally, 68% favored occupancy monitoring, highlighting its effectiveness in reducing congestion. Meanwhile, 55% appreciated real-time traffic updates, though it received the lowest support among the three interventions, suggesting potential areas for improvement.

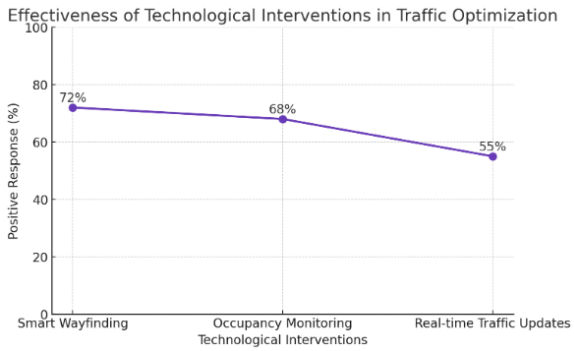


Figure 6: a line graph showing the impact of technological interventions.

3.3 Summary of Findings

The findings indicate that store placement significantly influences pedestrian flow, with congestion occurring near clustered anchor stores. Escalators are the preferred vertical circulation method, but bottlenecks often form around landing areas, while staircases remain underutilized. Public seating is essential for visitors, yet its poor placement contributes to congestion, and ineffective wayfinding leads to navigation challenges. Technological interventions such as smart wayfinding and occupancy monitoring improve traffic management, but traditional navigation methods are still relied upon by a significant portion of visitors. These insights highlight the need for balanced spatial planning, better circulation design, and improved integration of technology to enhance shopping mall efficiency.

4.0 Conclusion and Recommendations

The study highlights that spatial configuration, store placement, and vertical circulation elements significantly impact pedestrian flow and congestion in shopping malls. Poor wayfinding systems and inefficiently placed public spaces contribute to navigation difficulties and crowding. While technological interventions like smart wayfinding and occupancy monitoring improve traffic management, a notable percentage of visitors still rely on traditional navigation methods, indicating the need for a balanced approach. To enhance circulation efficiency, mall designs should incorporate evenly distributed anchor stores, optimize escalator and elevator placement, and encourage staircase use through better accessibility. Clear and strategically positioned wayfinding systems should be implemented to aid navigation. Additionally, integrating advanced digital solutions alongside traditional signage will accommodate varying levels of technological adaptability. Improving public seating arrangements and expanding smart traffic monitoring systems will further enhance visitor experience and reduce congestion.

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